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INDIAN NOTES  
AND MONOGRAPHS

EDITED BY F. W. HODGE

No.



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A SERIES OF PUBLICA-  
TIONS RELATING TO THE  
AMERICAN ABORIGINES

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DECLINATION OF THE PARS BAS-  
ILARIS IN NORMAL AND IN  
ARTIFICIALLY DEFORMED  
SKULLS

BY  
BRUNO OETTEKING

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NEW YORK  
MUSEUM OF THE AMERICAN INDIAN  
HEYE FOUNDATION  
1924

THIS series of INDIAN NOTES AND MONOGRAPHS is devoted primarily to the publication of the result of studies by members of the staff of the Museum of the American Indian, Heye Foundation, and is uniform with HISPANIC NOTES AND MONOGRAPHS, published by the Hispanic Society of America, with which organization this Museum is in cordial coöperation.

*Museum of the American Indian,  
Heye Foundation,  
Broadway at 155th St.,  
New York City.*

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# DECLINATION OF THE PARS BASILARIS IN NORMAL AND IN ARTIFICIALLY DEFORMED SKULLS<sup>1</sup>

A STUDY BASED ON SKULLS OF THE CHUMASH  
OF SAN MIGUEL ISLAND, CALIFORNIA,  
AND ON THOSE OF THE CHINOOK

BY BRUNO OETTEKING

## 1. INTRODUCTION



THE declination of the pars basilaris of the human occipitale is the result of the phylogenetically important flexion of the cranial base in the sagittal sense, which in turn is caused by the enormously expanding brain and the acquirement of the erect posture. The mechanical changes during this process quite probably take place in such a way that the transverse axis of flexion must be laid into the spheno-basilar fissure, while other processes, like the displacement of the foramen magnum downward and forward, go hand in hand with it.

Instead of following up the full effects of these changes the declination of the pars basilaris alone and its relation to other measurable morphological conditions at the base of the skull are to be the subject of a special investi-

<sup>1</sup> In its original (German) form this investigation represents a contribution to the Anniversary Volume for Prof. Rud. Martin of Munich, presented to him by his colleagues and pupils on the occasion of his sixtieth birthday, July 1, 1924.

gation. For a more precise examination of these conditions, skull series from San Miguel island, California, and from the lower course of Columbia river, Washington, were used. The first named is contained in the collections of the Museum of the American Indian, Heye Foundation, and consists of eighty-one skulls of the Chumash, of which sixty-seven are male and fourteen female. The second series belongs to the American Museum of Natural History, also in New York. It numbers eighty-three skulls of the Chinook, fifty-seven males and twenty-six females. It is well known that this tribe practised in an extreme degree antero-posterior deformation of the heads of infants. Observations on these strongly deformed skulls are therefore particularly adapted to a comparison with those on normal skulls.

## 2. METRICAL INVESTIGATION

The technique of measurement herein employed is in accordance with the method recommended by *Rudolf Martin* (1914).

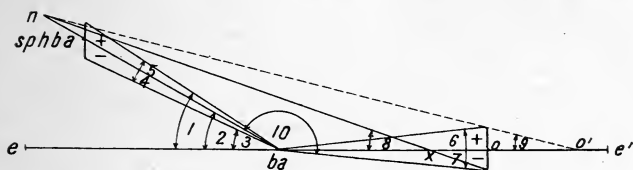
Since in the present investigation only angular conditions are treated, a determination of their relation to the ear-eye plane, or rather to a parallel of it laid through the basion, is necessitated. The basion therefore forms the vertex point of all the angles taken, and of which a certain relationship with the declination of the pars basilaris could be expected. Only one of the angles has its vertex at the opisthion. The angles are enumerated in the accompanying scheme and are informative with respect to the following conditions:

- a. Declination of the pars basilaris:  $< sphba-ba-e$ . Following the precedents of *Ranke* (1892, 38) and *Fr. Sarasin* (1916-22, 251), the underside of the pars basilaris was used in preference to the clivus line. Both form different angles to the ear-eye plane, which are definitely related to one another. Before all else, however, the sphenobasion-basion line is more convenient to ascertain, a point also emphasized by *Fr. Sarasin*.

The craniogram was extensively used. This method seemed to give better satisfaction in this specific case than that of direct measurement with sliding calipers and "Ansteckgoniometer" (clamp-on goniometer), for the reason that in some cases the underside of the pars basilaris is quite uneven and the basion drawn in.

- b. Declination of the basis cranii:  $< n-ba-e$ .

- c. Difference between the declinations of lines *a* and



*Measurement scheme.* Explanation of signs:  $e-e'$  = parallel to ear-eye plane laid through basion;  $ba$  = basion;  $sphba$  = sphenobasion;  $n$  = nasion;  $o, o'$  = opisthion;  $x$  = intersection of  $n-o$  line and ear-eye plane.

- $< 1$  and  $3$ : declination of pars basilaris.
- $< 2$ : declination of basis cranii.
- $< 4$  and  $5$ : difference between  $1$  and  $2$ , and  $3$  and  $2$ .  $+$  and  $-$ , deviation of pars basilaris from basis cranii line.
- $< 6$  and  $7$ : declination of foramen magnum plane.
- $< 8$  and  $9$ : declination of nasion-opisthion line.
- $< 10$ : Broca's "angle basilaire."

- b.*  $< n\text{-}ba\text{-}sphba$ . The declination of the spheno-basion-basion line upon the ear-eye plane may be less or greater than that of the nasion-basion line. This is best indicated by a plus (+) or a minus (−) sign, as signified in the scheme of measurements. Naturally, equality of both lines is also to be met.
- d.* Angle formed by the foramen magnum and ear-eye planes:  $< e'\text{-}ba\text{-}o$ .  
The angle is of phylogenetic importance, and is to be found either above or below the basion-parallel of the ear-eye plane. These conditions are indicated by a plus or a minus sign, as signified in the scheme of measurements.
- e.* Angular relation between the cranial base line and the foramen magnum plane (angle basilaire *Broca*):  $< n\text{-}ba\text{-}o$ .
- f.* Declination of the nasion-opisthion line upon the ear-eye plane:  $< n\text{-}x\text{-}ba$ .
- g.* Correlation between the pars basilaris and foramen magnum declinations.
- h.* Correlation between the pars basilaris declination and prognathism.

The metrical results derived from the investigations according to the foregoing plan will be discussed in the following paragraphs.

#### *A. Declination of the pars basilaris*

The declination of the pars basilaris upon the ear-eye plane in the San Miguel series yields a male average of  $32.0^\circ$ , and a female average of  $29.8^\circ$ , at variations



ranging from  $19-46^{\circ}$ , and  $22-38^{\circ}$  in the sexes. Compared with these figures, those of the Chinook appear depressed, their averages amounting to  $26.9^{\circ}$  and  $27.5^{\circ}$ . This is also manifested by the ranges which decline to  $14^{\circ}$  in women and  $18^{\circ}$  in men, ascending to  $42^{\circ}$  in the former and  $39^{\circ}$  in the latter. The excess over the otherwise highest female value of  $35^{\circ}$  is caused in their range by two extreme individual values of  $40^{\circ}$  and  $42^{\circ}$ . However, they influence the average only very slightly, i.e., not even to the amount of a unit. Without the two extreme values the female average amounts to  $26.8^{\circ}$ .

For the pars basilaris angle, *Fr. Sarasin* has proposed the following classification:

hyperplatyclin.....	x— $30^{\circ}$
platyclin.....	$30.1-35^{\circ}$
metrioclin.....	$35.1-40^{\circ}$
orthoclin.....	$40.1-45^{\circ}$
hyperorthoclin.....	$45.1-x$

According to this classification the male skulls from San Miguel island show a platyclin average, while the female ones are just hyperplatyclin. The percental distribution of the values of both series among *Sarasin's* classes is shown in the accompanying table.

In this table is seen particularly the preponderance of the Chinook toward the platyclin side. Their 95% are opposed to 80% of the San Miguel skulls; but, quite significantly, 78% of the former are hyperplatyclin, against only 43% in the latter. No less significant are the proportions in the metrioclin division, where 12% stand against 2%; and also in the orthoclin, with 7% against 2% in both series.

DECLINATION OF PARS BASILARIS	SAN MIGUEL ISLAND					CHINOOK				
	cases		per cent			cases		per cent		
	♂	♀	♂	♀	♂+ ♀	♂	♀	♂	♀	♂+ ♀
hyperplatyclin....	26	9	38.8	64.3	43.2	47	18	82.5	69.2	78.3
platyclin.....	27	3	40.3	21.4	37.0	8	6	14.0	23.1	16.9
metrioclin.....	8	2	11.9	14.3	12.3	2	—	3.5	—	2.4
orthoclin.....	5	—	7.5	—	6.2	—	2	—	7.7	2.4
hyperorthoclin....	1	—	1.5	—	1.2	—	—	—	—	—

Contrasting with these figures *Ranke's* (p. 66) and *Fr. Sarasin's* (p. 251) averages of 45° and 42.8° for Europeans, the considerably greater declination of the pars basilaris of more than 10° in our non-deformed series becomes quite conspicuous. It approximates, however, *Fr. Sarasin's* averages of New Caledonia men of 32.8°, and women of 31.3°. According to the special investigations thus far undertaken, the angle of declination seems to be slightly smaller in the female skull than in the male.

#### B. Declination of the basis cranii.

The angle of the nasion-basion, the so-called cranial base line with the ear-eye line, shows ranges in most human groups which rarely exceed 10°. As a rule the ranges keep below this figure. In the San Miguel series they extend between the values of 25° and 35° for men, and 25° and 34° for women, with uniform averages of 30.2°. As in the declination of the pars basilaris, that of the basis cranii of the Chinook appears also depressed.

In men it amounts to  $28.3^{\circ}$  and in women to  $29.2^{\circ}$ , with variations of  $23-35^{\circ}$  in the former and  $25-35^{\circ}$  in the latter. The differences between the averages of the two groups are not suggested by their ranges, which are fairly alike. Our averages fall quite high within the racial averages as given by *Martin* (1914, 484), with  $25.3^{\circ}$  (Torgotes) to  $30.5^{\circ}$  (Chinese), and by *Lüthy* (1912, 27), with  $26.7^{\circ}$  (Singhalese) to  $29.0^{\circ}$  (Papua and Australians), and this holds true also for the deformed Chinook. Considering also the findings on tribes of the North Pacific coast<sup>1</sup> with averages for both sexes of the Salish of  $30.2^{\circ}$  and  $29.9^{\circ}$ , Eskimo of Alaska even  $31.6^{\circ}$  and  $31.0^{\circ}$ , Haida of  $29.9^{\circ}$  and  $29.5^{\circ}$ , one is tempted to assign a relatively steeper cranial base to peoples of Mongoloid extraction. More extended examination must ascertain whether this latter assumption be correct. A strong declination of the cranial base line is, on the contrary, occasionally met in other groups. *Toldt* (1919, 46), for instance, describes a cranial base angle of  $19^{\circ}$  in an old Egyptian, indicating a condition of extreme flatness, which is still more intensified by the position in one plane of the sphenobasion, basion, and opisthion.

*C. Differences of declination between pars basilaris and basis cranii*

For the reason of greater stability of the nasion-basion line, the differences of declination of the sphenobasion-basion line were referred to it. The investigation

<sup>1</sup> The North Pacific data are from the author's report on the skeletal material of the Jesup Expedition, soon to be published.

showed that the minus-deviations in the San Miguel series, with male and female averages of  $-3.2^\circ$  and  $-3.4^\circ$ , are less pronounced than those for the plus-deviations of  $+6.0^\circ$  and  $+5.5^\circ$ . This condition is reversed in the Chinook, whose minus- and plus-deviations in both sexes amount to  $-5.2^\circ$  and  $-8.1^\circ$ , and to  $+4.0^\circ$  and  $+5.0^\circ$ . In the latter series, however, the equality of both lines exceeds, in its 38 individuals, that of the San Miguel series with only 21. The variations result accordingly, ranging from  $-9^\circ$  to  $+15^\circ$  in the San Miguel Indians and from  $-14^\circ$  to  $+8^\circ$  in the Chinook. This shift toward the minus side is likewise manifested in the total averages, with  $+1.5^\circ$  against  $-0.7^\circ$ .

These conditions also find expression in the following table of total means for both sexes of the two series, as well as by their differences. The latter show in horizontal order the preponderance of the pars basilaris angle over the basis cranii angle in the San Miguel series, resulting in a plus-difference, while in all these conditions the opposite occurs in the Chinook. In the vertical order all the differences are shown to be in favor of the San Miguel series.

TRIBE	DECLINATION ( $\sigma + \varphi$ )		difference	$\begin{matrix} < \\ n-ba-sphba \end{matrix}$
	<i>pars basilaris</i>	<i>basis cranii</i>		
San Miguel.....	$31.6^\circ$	$30.2^\circ$	$+1.4^\circ$	$+1.5^\circ$
Chinook.....	$27.2''$	$28.5''$	$-1.3''$	$-0.7''$
Difference....	$4.4^\circ$	$1.7^\circ$	$+0.1^\circ$	$+0.8^\circ$

*D. Foramen magnum angle*

Among others it is particularly *Bolk* (1909, 1915) who has lucidly explained the organic reasons for the displacement of the foramen magnum within the primate line. It is also known that within the *Homo* group the angle of declination between the foramen magnum and ear-eye planes differs racially, since from primitive toward higher morphological conditions the foramen magnum acquires a steeper position, i.e., sinks off posteriorly. In Chapelle-aux-Saints, for instance, this angle is only  $+7^\circ$ . Reminiscences of a more primitive condition, signified by a plus sign in front of the figure that indicates the size of the angle (see under *d* of the measurement plan and scheme, page 5) occur likewise in morphologically less developed varieties.

In the San Miguel series variation in the men starts as low as  $+3^\circ$ , while the lowest individual value in the women is  $-5^\circ$ . Toward the other extreme the male range reaches  $-21^\circ$  and the female range  $-22^\circ$  as their highest values. In the former, the average amounts to  $-9.4^\circ$ , rising on the latter to  $-13.2^\circ$ . In the deformed skulls of the Chinook, the averages fall considerably lower. With averages of  $+0.6^\circ$  in men and  $-0.5^\circ$  in women, their foramen magnum plane almost coincides with the horizontal. In spite of this the ranges are quite extended, reaching from  $+14^\circ$  to  $-15^\circ$  and from  $+7^\circ$  to  $-10^\circ$  in the two sexes. Characteristic in these deformed skulls likewise is the slight excess of the female over the male averages, which indeed seems to be the general condition. This

statement is corroborated by the Eskimo of Alaska, who are included in the following table:

TRIBE	FORAMEN MAGNUM ANGLE					
	Male			Female		
	Cases	Average	Variation	Cases	Average	Variation
San Miguel Island....	67	-9.4°	+3° to -21°	14	-13.2°	-5° to -22"
Chinook....	56	+0.6"	+14" to -15"	24	-0.5"	+7" to -10"
Eskimo (western)	32	-7.1"	+2" to -19"	12	-9.8"	-4" to -20"

*E. Broca's basis angle (angle basilaire)*

From the point of view of correlation claimed by *Ranke*, of the deviation of the two basis lines (nasion-basion and sphenobasion-basion), *Broca's* basis angle is also of interest. In the wider sense it is to be considered as a reiteration of the angular conditions already discussed, of the two components forming it, namely, the cranial basis (nasion-basion) and the foramen magnum plane. The higher averages of the latter plane shown for the female skulls of our two series are also to be noticed in *Broca's* basis angle as compared with the more stable conditions in the declination of the cranial basis (nasion-basion), i.e., they yield higher means likewise for the basis angle of *Broca*. In the Chinook these means are markedly lower, not so much on account of, but rather in spite of, the more pronounced declination of the

cranial base line, because of the nearly horizontal position of the foramen magnum plane. The male means of the San Miguel and Chinook series are as  $159.8^{\circ}$  to  $149.6^{\circ}$ , the female means as  $162.1^{\circ}$  to  $151.5^{\circ}$ . In accordance with the average conditions are the variations from which they are derived, and which may be seen from the following table:

TRIBE	BROCA'S BASIS ANGLE					
	Male			Female		
	<i>cases</i>	<i>average</i>	<i>variation</i>	<i>cases</i>	<i>average</i>	<i>variation</i>
San Miguel Island.....	66	$159.8^{\circ}$	$150-173^{\circ}$	13	$162.1^{\circ}$	$153-171^{\circ}$
Chinook.....	56	$149.6^{\circ}$	$139-167^{\circ}$	23	$151.5^{\circ}$	$143-164^{\circ}$

From the comparative table in *Lüthy's* work (p. 35), the distinctive position among his European groups of the Bündner with reference to *Broca's* basis angle is obvious. With an average of  $163.5^{\circ}$  they exceed all non-Europeans by  $4-11^{\circ}$ , possessing also the larger foramen magnum angles of  $11.1^{\circ}$ . If this condition is directly indicative of the displacement of the opisthion in the sense of phylogenetic development, *Lüthy*, on the other hand, was able to prove the low position of the basion by the declination of the basion-opisthion line which he found similar to that of other groups. The low position of the basion he recognized in the Cameroon negroes with a basis angle of  $152.0^{\circ}$ , and per-

haps also in the Battaks with one of  $156.0^{\circ}$ . Our San Miguel series approximates in this respect the course pursued by the Europeans.

*F. Declination of the basion-opisthion line on the ear-eye plane*

The nasion-opisthion angle is quite variable in our two series. The averages of  $24.5^{\circ}$  and  $25.0^{\circ}$  for the male and female San Miguel Indians are rather high, while the individual variation is limited to (18)  $21-30^{\circ}$  in the former and  $22-29^{\circ}$  in the latter. The averages combine themselves with good-sized angles of the foramen magnum and the cranial base, and from such conditions the low position of the opisthion might be concluded, which would be in keeping with the natural phylogenetic development of that region. The Chinook turn out somewhat differently, with nasion-opisthion angles of  $20.7^{\circ}$  and  $21.5^{\circ}$  in both sexes, the individual variation ranging from  $17-25^{\circ}$  and  $18-25^{\circ}$ . Considering the depressed condition of the foramen magnum plane and the cranial basis line as affected by deformation, the question rises independently as to the displacement of the form elements at the cranial base.

It is to be assumed that under normal conditions, i.e., among non-deformed Chinook, results should be attained similar to those from the San Miguel skulls. Since, however, the discussion of other related measurements has already proved a distortion of form elements in this connection, the problem changes as to the question whether by the distortion the basion or the opisthion,



or both, yielded to the pressure into a lower position. The accompanying table of angular relations of the elements concerned, with the ear-eye horizontal, demonstrates that in the San Miguel skulls a stronger minus-deviation of the foramen magnum plane combines itself with a higher nasion-opisthion angle. For the latter, *Lüthy* (p. 35) gives averages ranging from 21.4 to 24.1°. Since, however, the declination of the pars basilaris is platyclin at the same time, i.e., relatively great, normal conditions seem to prevail here for the San Miguel skulls. The most significant differences between the two series treated are the diminished angles of the participating pars basilaris, cranial basis, and nasion-opisthion line, and the horizontal position of the foramen magnum plane. Without going far amiss, one may recognize

SERIES	ANGLES WITH EAR-EYE PLANE (♂ + ♀) OF:			
	<i>pars basilaris</i>	<i>cranial basis</i>	<i>foramen- magnum plane</i>	<i>nasion- opisthion line</i>
San Miguel				
Island.....	31.6°	30.2°	-10.0°	24.8°
Chinook.....	27.2''	28.5'	+0.3''	20.9''

these changes in the Chinook as effects of extreme deformation, favored even in the case of the pars basilaris by the not yet obliterated speno-basilar fissure. Unaccounted for would then remain the question as to what caused the changes in the behavior of the foramen magnum plane. It is to be considered here that in a certain sense the anterior as well as the posterior margin of the foramen magnum lacks direct points of

support, thus yielding to pressure in a moderate way. More so than for the anterior margin, this is true for the posterior one, where the effect of pressure is much more direct by neck cushions used in deformation. One may be justified then in concluding that the diminution of the pars basilaris angle in the Chinook by fully  $4^{\circ}$  as compared with the San Miguel skulls, is the indirect effect of artificial deformation, responsible also for the lower position of the basion. The displacement of the opisthion in the infantile head, on the other hand, must be considered a much more intensive one, causing on an average the horizontal direction of the foramen magnum plane.

In this connection it should be mentioned that *Fr. Sarasin's* classification of the pars basilaris declination shows disproportions with the degree of declination of the cranial basis line. Thus, while in the San Miguel series the total average of the former with  $31.6^{\circ}$  turns out to be platyclin, the declination of the cranial basis amounts to  $30.2^{\circ}$ , which is near the upper border line for the values of the latter measurement. Yet it must be remembered that the behavior of the angle of cranio-basal declination depends on the length of the cranial basis line and in a certain sense the configurative structure of the facial skull. A systematic investigation into this problem would be desirable.

*G. Correlation between the declination of the pars basilaris and foramen magnum*

The investigation of the mutual dependency of the declinations of the pars basilaris and foramen magnum

has not yielded unequivocal results. The investigation was conducted in such a way that for certain consecutive sections of the range of variation of the pars basilaris declination, the averages of the coinciding foramen magnum angles of the males and the females, and of both sexes combined, were computed. The accompanying table (page 18) presents the results.

In the San Miguel male skulls an increase of averages is to be noted between the first two classes, followed in the third one by a relapse to the average of the first, and a renewed increase in the fourth class to the figure of the second. In the female skulls a decrease of averages takes place between the first three classes, and then an increase to almost the same height as the first. But it must be remembered that the two outer groups comprise only two individuals each. In both sexes the total averages behave proportionately, like those of the males, although they are increased on account of the higher female values. The combination of the two middle classes of the total averages results in equal values of  $-10^{\circ}$ , to which the outer classes add decimals. This apparent stability of correlation and the instability in the sex classes afford the reason why gradual progression of mutual relations is missing here.

That the same holds true for the Chinook needs no particular explanation. Even the prevalence of the female over the male values, as noticed in the San Miguel skulls, does occur there, and the results of the triple division in the last column of our table are devoid of even a suggestion of correlation.

SAN MIGUEL ISLAND									
FORAMEN MAGNUM ANGLE									
Declina- tion of pars basilaris	male			female			$\sigma + \varphi$		
	cases	average	variation	cases	average	variation			
19-25°	6	-8.2°	-2° to -14°	2	-18.5°	-18°;	-10.8"	-10.8°	
26-30°	20	-10.8"	0" to -21"	7	-12.6"	-6" to -22"	-11.2"	-10.0°	
31-35"	27	-8.1"	+3" to -20"	3	-9.3"	-5" to -13"	-8.0"		
36-46"	12	-10.0"	-4" to -20"	2	-16.0"	-13"; -19"	-10.6"	-10.6°	
CHINOOK									
14-20°	6	-5.0°	-2° to -14°	2	0.0°	+3°;	-3.8°	-3.8°	
21-25"	14	+2.4"	+9" to -8"	7	-2.0"	+4" to -9"	+0.9"	+1.0°	
26-30"	26	+1.0"	+14" to -15"	9	+1.6"	+7" to -5"	+1.1"		
31-42"	10	+0.8"	+9" to -12"	8	-1.5"	+4" to -9"	-0.2"	-0.2°	

*H. Declination of the pars basilaris and prognathism*

It will be remembered that *Virchow* and *Ranke* had assumed in man an increase of prognathism with the increasing flexion of the cranial basis, which assumption could not be maintained, however, after a reëxamination of these conditions by *Welcker*. The investigations conducted in this paper did not attack that problem anew, but it seemed to be of particular interest to examine the declination of the pars basilaris in connection with prognathism. For this purpose the three profile angles—facial, nasal and alveolar—have been correlated with a triple division of the range of variation of the pars basilaris declination and listed in the following table:

Declination of pars basilaris	PROFILE ANGLES (♂ + ♀)						
	SAN MIGUEL ISLAND			Declination of pars basilaris	CHINOOK		
	Total	Nasal	Alveolar		Total	Nasal	Alveolar
19-25°	80.5°	82.0°	75.6°	14-20°	80.1°	81.6°	74.1°
26-35"	80.9"	83.4"	75.0"	21-30"	80.7"	82.2"	75.1"
36-46"	80.3"	82.1"	75.1"	31-42"	79.5"	81.4"	72.8"

In the two series the angles differ between themselves in the well-known fashion: the nasal profile angle exceeds the other two in size, and the alveolar angle falls short of the total and nasal angles. Conspicuous in the San Miguel Island skulls is the uniformity of the total profile angle for the three divisions of the pars basilaris declination, especially as that angle includes the alveolar one which as a rule shows wider variations. The average of the nasal profile angle increases to 83.4°, only to conform

again in the third division to the lower average of the first. A slight increase, then, of the nasal profile angle is to be recognized as the pars basilaris angle grows, but which is not continued with the further increase of this angle. In the Chinook series the uniformity of the total profile angle is all the more peculiar since it is derived from conditions disturbed by deformation. Although there is here a difference of about  $5^{\circ}$  as compared with the San Miguel series, the averages of both groups are nevertheless equal. The slight decrease of the average to  $79.5^{\circ}$  for the division of least declination of the pars basilaris is in a way correlated with the smallest average of alveolar declination at  $72.8^{\circ}$ , but a gradual decrease of the alveolar angle in connection with the pars basilaris declination does not take place. The behavior of the nasal profile angle resembles that of the San Miguel skulls: after a slight increase of the average, shared in this series by the averages of the total and alveolar profile angles, a slight decrease toward the third group and with the increasing high position of the pars basilaris is to be noticed. Mechanically, this indication of a correlation might be explained in such a way that, under conservation of the angular conditions of the nasion-prosthion and sphenobasion-basion lines, the latter to be considered equivalent to the nasion-basion line, the basion being pressed downward, a one-sided distortion by a sort of rotation was caused, manifesting itself in the erection of the pars basilaris and a stronger declination of the alveolar profile line.

The measurements discussed in the preceding paragraphs are for convenience listed in our final table:

TABLE OF ANGLES (NUMBER OF CASES, AVERAGES, VARIATION AND STANDARD DEVIATION)

Angles	SAN MIGUEL ISLAND				CHINOOK			
	cases	average	variation	$\sigma$	cases	average	variation	$\sigma$
Pars basilaris								
♂.....	67	32.0°	19-46°	} ± 5.06	57	26.9°	18-39°	} ± 4.47
♀.....	14	29.8"	20-38"		26	27.5"	14-42"	
Basis cranii								
♂.....	67	30.2°	25-35°	} ± 2.02	56	28.3°	23-35°	} ± 2.44
♀.....	14	30.2"	25-34"		24	29.2"	25-35"	
Pars basilaris to basis cranii								
♂.....	67	+1.2°	+15 to -9°	} ± 4.66	58	-0.6°	+ 8 to -11°	} ± 4.34
♀.....	14	+0.6"	+ 9 to -7"		23	-1.0"	+ 7 to -14"	
Foramen magnum								
♂.....	67	-9.4°	+ 3 to -21°	} ± 5.27	56	+0.6°	+14 to -15°	} ± 5.64
♀.....	14	-13.2"	- 5 to -22"		24	-0.5"	+ 7 to -14"	
Angle basilaire of Broca								
♂.....	66	159.8°	150-173°	} ± 5.77	56	149.6°	139-167°	} ± 6.34
♀.....	13	162.1"	153-171"		23	151.5"	143-164"	
Nasion-opisthion line								
♂.....	67	24.5°	18-30°	} ± 2.27	57	20.7°	17-25°	} ± 2.15
♀.....	14	25.9"	22-39"		24	21.5"	18-25"	

## 3. DISCUSSION AND RESULTS

The declination of the pars basilaris of the occipital bone, as a condition rooted in human ontogeny, does not include alone the ontogenetic anlage of rudimentary vertebral corpora, but also the flexion of the cranial basis as resulting from the enormous increase of the brain noticeable in early phases of growth. This process is favored by the open condition of the spheno-basilar fissure, which latter, in analogy to the dia-epiphysis conditions of the longbones, must be understood as true growth areas. Besides other manifestations at the cranial basis, as, for instance, the depression of the petrous parts below the niveau of the surrounding parts and the diminution of their mutual angularity, the erection of the pars basilaris must be considered a progressive character. Special investigations have shown that it is most pronounced in Europeans. Sex differences as manifested by a stronger flexion or kyphosis of the cranial basis in man as contrasted with a more leveled position or orthosis in women, have been established for a number of human groups, and hold true for the series of Indian skulls discussed in this paper. The declination of the pars basilaris (sphenobasion-basion) either coincides with that of the cranial basis (nasion-basion) or is smaller or greater. Possible reasons therefore have not been discussed here, but it is quite probable that in a systematic investigation the proportion and configuration of the participating parts will be of specific importance. The foramen magnum angle, which is included in the present investigations, does not show in the two



series any definite correlation with the declination of the pars basilaris. The gradual sloping of the foramen magnum plane, then, an ontogenetically as well as a phylogenetically important process, is not correlated with the erection of the pars basilaris. The latter, as well as the foramen magnum declination, has rotation axes situated in the spheno-basilar fissure and the basion. While the latter point is at the same time to be considered as mobile, i.e., yielding to the expansive pressure of the brain, such an assumption receives renewed justification through the probable displacement of the basion downward through mechanical pressure in artificial deformation simultaneously with that of the opisthion upward. Both processes result, in the Chinook series, in the horizontal direction of the foramen magnum plane. Anteriorly this change is already initiated in the Chinook by the yielding of the pars basilaris in toto. *Broca's* angle basilaire turns out accordingly, expressing these conditions in a combinative way, comprising, however, the nasion-basion declination. But like the spheno-basion-basion declination in the Chinook skulls, their nasion-basion declination is likewise influenced by artificial deformation.

Still less correlated than the pars basilaris and foramen magnum declinations, seem to be the former and prognathism. And this holds good not only for the two series as such, but also within each. The uniformity of findings is astonishing, although derived from normal and artificially deformed skulls. In addition to the same genetic derivation, the sparsity of the material is another point to be considered. It is not expected that

more numerous and homogeneous collections will materially change the nature of the findings. Racially different series, however, may also yield different results in the problem discussed, results already obtained in a number of other measurable quantities.

Summarizing, our investigations have led to the following conclusions:

1. The declination of the pars basilaris in the normal skulls from San Miguel Island and in the artificially deformed skulls of the Chinook is greater than in Europeans, i.e., platyclin against orthoclin.

2. In the Chinook, the declination of the pars basilaris is distinctly influenced by deformation, causing a hyperplatyclin instead of a platyclin condition.

3. Like the pars basilaris declination (sphenobasion-basion), the deformation affects also the cranial basis (nasion-basion), and the foramen magnum declination, i.e., its anterior fixed point, while the posterior one, the opisthion, is pushed upward by a special deforming device.

4. No unequivocal correlations obtain in the two series, either between the pars basilaris declination ~~or~~<sup>and</sup> that of the foramen magnum, or between the first and the three profile angles.

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